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Multi-Camera Activation Scheme for Target Tracking with Dynamic Active Camera Group and Virtual Grid-Based Target Recovery

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Abstract

Camera sensor activation schemes are essential for optimizing the usage of resources in wireless visual sensor networks. In this regard, an efficient camera sensor activation scheme which accounts for fast moving targets is proposed. This is achieved by adapting the number of cameras involved in tracking the target, based on the target's speed. To reduce the target miss rate, a virtual grid-based target recovery scheme is proposed, which attempts to re-locate the target in the case of a target miss. Simulations show that the proposed activation scheme gives a considerable reduction in target miss rate compared to an existing scheme which is based on observation correlation coefficient between camera sensors.

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Keywords: Camera activation scheme; Target tracking; Observation correlation coefficient; Virtual grid; Target recovery

1. INTRODUCTION

Wireless visual sensor networks (WVSN) comprise of many low-cost, battery-powered nodes (cameras) which wirelessly communicate with each other to perform tasks such as target detection, tracking and recognition. They are used in various areas like security, surveillance and also in military applications. One of the various challenges involved in WVSNs is the huge amount of data generated by the camera nodes in the network. It is impractical to transmit all the raw data captured by the sensors as this requires large bandwidth.

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Further, the processing and communication capabilities of the sensor nodes are not very powerful, since low-cost hardware is used. With these limitations, it should be ensured that the target is not missed, which is the prime purpose of tracking. Since all the cameras in a WVSN need not be always active, an efficient sensor activation scheme is needed which will activate only those camera sensors which carry relevant information about the target[1]. Since processing cost is significantly less than the communication cost, there is a need to use as much local processing as possible in each node[2].

In this paper, a camera activation scheme for target tracking is proposed, which improvises on the scheme proposed in. In [1], the author proposes the idea of observation correlation coefficient (OCC), which is based on the fact that, in a WVSN, it is highly likely that a target is captured by multiple cameras which have overlapping sensing regions. OCC defined for a pair of cameras gives a measure of the extent of overlap of their fields of view (FOV). So, rather than using raw images as in [3], the author in [1] has proposed to use OCC to activate the correlated camera pair.

The OCC-based activation scheme proposed in [1] activates a small group of cameras (3 in number) at each time step. This might not be sufficient to track a target moving with a high speed. In this paper, in an attempt to reduce target misses, an improved technique is proposed which employs a virtual grid-based target recovery (VGTR) scheme, with the number of active cameras varied proportionately with the target's speed.

2. EXISTING APPROACHES

Sensor scheduling strategies for energy-efficient target tracking have been proposed in [4]. But, these schemes require ceiling-mounted cameras, which are not always feasible in real-world scenarios. A Monte Carlo sampling approach for sensor scheduling has been considered in [5]. However, this holds good for generic wireless sensor networks, but is not suitable to be applied to WVSNs.

Medeiros et. al.[6] have considered local data aggregation as an effective means for target localization and tracking. However, this requires every node in the WVSN to be equipped with the resources capable of aggregating the data and localizing the target. This also involves a processing and communication overhead, since a cluster head election algorithm needs to be executed whenever the target moves out of the range of the current active camera cluster. Zarifneshat et. al.[7] have considered a cluster-based activation scheme, where the cluster head of the current active cluster is responsible for predicting the next location of the target and activating the next cluster head and appropriate sensor nodes at the predicted location. By this approach, the complexity is reduced than [6], since there is no cluster head election involved. However, the algorithm assumes a fixed cluster size, and a grid arrangement of cameras, which is not always feasible. Song et. al.[8] have proposed a consensus method for target tracking, which fuses the information from all the cameras viewing the same target. But in this approach, the target tracking accuracy is limited by the resources in the network as mentioned in [1].

The algorithm described in [1] uses a very small number of cameras, thereby minimizing the resource needed to track the target. However, this scheme does not account for tracking fast moving targets. In the present work, an attempt is made to track fast moving targets while preserving the essence of the method in [1].

3. BASELINE: OCC-BASED ACTIVATION SCHEME

The OCC-based activation scheme proposed in [1] is considered as the baseline algorithm. In this scheme, whenever a camera captures the target, it activates two other cameras which have maximum OCC with it. This scheme is briefly explained in the remainder of this section.